Table 1. Fatty acid profile of diets

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fatty acid  (g/100 g of total fatty acid) | LFD | HFD | LOW | REG |
| C4 | 0 | 0 | 1.2 | 1.6 |
| C6 | 0 | 0 | 0.3 | 0.8 |
| C8 | 0 | 0 | 0.4 | 0.4 |
| C10:0 | 0 | 0 | 0.7 | 0.9 |
| C12:0 | 0 | 0 | 0.5 | 0.8 |
| C14:0 | 1.4 | 1.4 | 2.6 | 5.6 |
| C15:0 | ND | ND | ND | ND |
| C16:0 | 27.1 | 27.7 | 28.0 | 28.9 |
| C17:0 | ND | ND | 0.3 | 0.3 |
| C16:1 n-9 | 1.7 | 1.8 | 2.2 | 2.2 |
| C18:0 | 15.4 | 16.0 | 13.3 | 11.8 |
| C18:1 t11 | ND | ND | ND | 0.7 |
| C18:1 n-9 | 33.4 | 34.6 | 30.3 | 27.3 |
| C18:2 n-6 (Linoleic Acid) | 14.5 | 13.8 | 12.3 | 12.2 |
| C18:3 n-3 (Linolenic Acid) | 2.7 | 1.1 | 1.2 | 1.4 |
| C18:3 n-6 | ND | ND | ND | 0.6 |
| Total SFA | 43.9 | 45.1 | 45.4 | 48.3 |
| Total MUFA | 35.1 | 36.4 | 32.5 | 30.2 |
| Total n-6 PUFA | 14.5 | 13.8 | 12.3 | 12.2 |
| Total n-3 PUFA | 2.7 | 1.1 | 1.2 | 1.4 |
| Ratio n-6:n-3 | 5.4 | 12.5 | 10.3 | 8.7 |
| Total PUFA | 17.2 | 14.9 | 13.5 | 13.6 |
| Ratio PUFA:SFA | 0.39 | 0.33 | 0.30 | 0.28 |

ND – not detected, less than 0.1%; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids

Table 2 Complete metabolomics analyses1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Metabolite (μM) | LFD | HFD | LOW | REG | p-value |
| *2-hydroxybutyrate* | *33.3 ± 5.7* | *36.2 ± 8.7* | *20.1 ± 3.6* | *34.4 ± 12.9* | *0.36* |
| *3-hydroxybutyrate* | *917 ± 196* | *1356 ± 170* | *1172 ± 141* | *1140 ± 118* | *0.15* |
| *Acetic acid* | *119.6 ± 14.4* | *120.2 ± 12.9* | *116.9 ± 7.5* | *110.1 ± 5.2* | *0.96* |
| *Acetoacetate* | *100.7 ± 15.3* | *122.6 ± 28.1* | *130.2 ± 31.6* | *116.5 ± 29.1* | *0.97* |
| *Acetone* | *1973 ± 282* | *2091 ± 183* | *2421 ± 390* | *1735 ± 429* | *0.25* |
| Acetylornithine | 0.36 ± 0.02ab | 0.28 ± 0.02a | 0.55 ± 0.06bc | 0.99 ± 0.02b | <0.001 |
| *L-Alanine* | *536.1 ± 60.1* | *440.7 ± 40.4* | *490.1 ± 35.1* | *629.5 ± 60.5* | *0.052* |
| Alanine | 534 ± 50ab | 365 ± 60a | 470 ± 41ab | 603 ± 56b | 0.023 |
| *L-Arginine* | *312.6 ± 31.1* | *340.3 ± 25.0* | *377.7 ± 23.9* | *329.2 ± 36.3* | *0.38* |
| *α-Aminoadipic acid* | *1.46 ± 0.15* | *1.37 ± 0.18* | *1.47 ± 0.12* | *1.39 ± 0.15* | *0.91* |
| Arginine | 312.0 ± 29.0 | 283.7 ± 41.9 | 372.3 ± 24.4 | 322.4 ± 35.6 | 0.37 |
| *L-Asparagine* | *90.0 ± 12.5* | *78.7 ± 8.9* | *92.2 ± 13.4* | *109.4 ± 19.7* | *0.13* |
| Asparagine | 81.0 ± 11.1 | 51.0 ± 8.0 | 77.3 ± 9.7 | 82.9 ± 8.6 | 0.10 |
| *Aspartic acid* | *28.4 ± 4.5a* | *25.0 ± 3.2a* | *41.3 ± 6.1ab* | *51.7 ± 8.5bc* | *0.005* |
| Aspartic acid | 27.0 ± 2.1ab | 19.2 ± 4.0a | 36.3 ± 4.7bd | 47.5 ± 5.8cd | 0.002 |
| *Betaine* | *124.3 ± 11.1* | *121.9 ± 7.5* | *132.5 ± 18.9* | *161.9 ± 26.7* | *0.53* |
| *L-Carnitine* | *39.4 ± 5.7* | *28.9 ± 2.4* | *31.4 ± 4.6* | *55.9 ± 12.2* | *0.15* |
| Carnosine | 2.34 ± 0.89 | 0.92 ± 0.19 | 1.66 ± 0.30 | 2.21 ± 0.75 | 0.46 |
| *Choline* | *30.8 ± 4.5a* | *212 ± 25.0b* | *33.0 ± 4.7a* | *45.3 ± 5.7a* | *<0.001* |
| *Citric acid* | *206.9 ± 21.8* | *228.0 ± 27.5* | *211.5 ± 25.0* | *267.0 ± 36.9* | *0.51* |
| Citruline | 57.5 ± 7.4 | 49.9 ± 6.1 | 57.3 ± 6.1 | 61.2 ± 6.6 | 0.27 |
| *Creatine* | *151.2 ± 41.0* | *205.2 ± 36.3* | *174.8 ± 30.8* | *226.8 ± 42.3* | *0.30* |
| *Creatinine* | *44.6 ± 5.7* | *34.9 ± 5.1* | *40.7 ± 4.9* | *40.7 ± 4.6* | *0.53* |
| Creatinine | 41.4 ± 6.6 | 33.3 ± 5.6 | 38.1 ± 4.5 | 66.6 ± 29.9 | 0.67 |
| Dimethyl arginine | 0.60 ± 0.06 | 0.49 ± 0.07 | 0.55 ± 0.06 | 0.67 ± 0.08 | 0.72 |
| *Dimethyl sulphone* | *3.2 ± 0.7* | *2.9 ± 0.4* | *3.3 ± 0.4* | *4.3 ± 0.9* | *0.44* |
| *Ethanol* | *127.4 ± 31.4* | *93.3 ± 11.9* | *88.2 ± 14.2* | *126.2 ± 26.4* | *0.59* |
| *Formate* | *42.6 ± 2.6* | *45.7 ± 2.1* | *45.7 ± 3.3* | *50.5 ± 3.2* | *0.30* |
| *D-Glucose* | *10512 ± 917* | *8610 ± 472* | *8210 ± 712* | *9686 ± 850* | *0.16* |
| *L-Glutamic acid* | *173.9 ± 34.4* | *154.1 ± 30.3* | *204.5 ± 37.7* | *253.6 ± 37.4* | *0.15* |
| Glutamic acid | 176.4 ± 36.2 | 125.9 ± 32.1 | 196.9 ± 37.7 | 231.7 ± 29.0 | 0.18 |
| *L-Glutamine* | *992 ± 183* | *1117 ± 69* | *1002 ± 85* | *1105 ± 48* | *0.45* |
| Glutamine | 1986 ± 89 | 938 ± 136 | 955 ± 69 | 1034 ± 41 | 0.52 |
| *Glycerol* | *304.9 ± 21.5* | *272.5 ± 28.1* | *294.1 ± 32.3* | *421.4 ± 104.5* | *0.38* |
| *Glycine* | *486.5 ± 90.6* | *449.1 ± 36.0* | *442.2 ± 46.6* | *426.3 ± 31.3* | *0.98* |
| Glycine | 381.8 ± 60.8 | 455.8 ± 75.7 | 393.9 ± 42.3 | 421.8 ± 50.3 | 0.88 |
| Histamine | 2.0 ± 0.1 | 1.0 ± 0.1 | 2.0 ± 0.01 | 1.9 ± 0.0 | 0.97 |
| Histidine | 80.2 ± 10.3 | 52.2 ± 7.5 | 71.3 ± 7.4 | 76.1 ± 6.4 | 0.16 |
| trans-Hydroxyproline | 25.9 ± 2.1 | 18.2 ± 2.7 | 24.1 ± 2.1 | 25.2 ± 2.6 | 0.36 |
| *Isobutyric acid* | *1.3 ± 0.3* | *1.7 ± 0.9* | *1.4 ± 0.7* | *2.9 ± 1.4* | *0.74* |
| *Isoleucine* | *117.1 ± 6.3* | *128.0 ± 12.6* | *132.3 ± 16.2* | *166.4 ± 30.0* | *0.25* |
| Isoleucine | 121.8 ± 8.0 | 102.6 ± 14.7 | 131.3 ± 12.1 | 158.4 ± 36.7 | 0.45 |
| Kynurenine | 4.0 ± 1.1 | 2.2 ± 0.4 | 4.1 ± 1.0 | 4.2 ± 0. 9 | 0.36 |
| *L-Lactic acid* | *4250 ± 751ab* | *3887 ± 432a* | *5148 ± 551ab* | *7068 ± 1304b* | *0.02* |
| *L-Leucine* | *387.4 ± 26.7* | *365.6 ± 34.7* | *397.4 ± 23.2* | *470.2 ± 39.8* | *0.14* |
| *Leucine* | *391.4 ± 35.2* | *324.1 ± 52.6* | *372.1 ± 25.5* | *453.1 ± 37.7* | *0.24* |
| *L-Lysine* | *422.9 ± 52.1* | *413.8 ± 28.1* | *417.5 ± 27.2* | *521.1 ± 45.3* | *0.17* |
| Lysine | 407.4 ± 50.8 | 348.6 ± 53.1 | 399.4 ± 23.7 | 510.9 ± 37.5 | 0.07 |
| *Malonate* | *10.0 ± 1.4* | *7.2 ± 0.8* | *8.6 ± 1.2* | *12.2 ± 4.7* | *0.48* |
| *Methanol* | *147.5 ± 21.8* | *77.4 ± 27.2* | *105.8 ± 36.5* | *153.8 ± 37.0* | *0.13* |
| *Methionine* | *98.9 ± 9.2* | *90.5 ± 7.7* | *95.2 ± 7.0* | *110.8 ± 7.1* | *0.26* |
| Methionine | 96.7 ± 9.3 | 76.2 ± 12.7 | 94.3 ± 8.2 | 103.3 ± 10.4 | 0.51 |
| Ornithine | 70.3 ± 9.1a | 46.1 ± 6.7ab | 77.4± 4.4b | 95.7 ± 14.3b | 0.004 |
| *L-Phenylalanine* | *88.4 ± 5.8* | *78.4 ± 4.9* | *87.3 ± 8.4* | *114.1 ± 20.6* | *0.14* |
| Phenylalanine | 84.5 ± 6.5 | 61.9 ± 8.9 | 84.4 ± 8.5 | 106.0 ± 19.1 | 0.08 |
| *L-Proline* | *303.4 ± 17.3* | *280.9 ± 35.2* | *270.3. ± 26.7* | *327.8 ± 29.3* | *0.37* |
| Proline | 297.6 ± 23.0 | 216.5 ± 38.5 | 257.8 ± 22.6 | 315.5 ± 23.3 | 0.11 |
| Putrescine | 1.24 ± 0.13 | 0.99 ± 0.14 | 1.29 ± 0.17 | 1.35 ± 0.15 | 0.60 |
| *Pyruvic acid* | *118.4 ± 36.3* | *86.3 ± 17.4* | *132.9 ± 18.8* | *173.0 ± 27.2* | *0.14* |
| *L-Serine* | *393.4 ± 71.3* | *346.3 ± 26.7* | *295.1 ± 30.0* | *448.3 ± 66.6* | *0.13* |
| Serine | 291.1 ± 63.0 | 285.6 ± 46.4 | 294.0 ± 30.5 | 426.8 ± 67.3 | 0.19 |
| Serotonin | 9.03 ± 0.85 | 7.75 ± 1.71 | 7.26 ± 1.09 | 7.77 ± 1.58 | 0.54 |
| Spermidine | 3.29 ± 0.48 | 2.37 ± 0.39 | 3.52 ± 0.65 | 2.99 ± 0.80 | 0.47 |
| Spermine | 0.50 ± 0.08 | 0.36 ± 0.02 | 0.49 ± 0.10 | 0.55 ± 0.10 | 0.24 |
| Succinate | 18.9 ± 3.7 | 16.0 ± 1.9 | 23.1 ± 3.0 | 45.3 ± 22.3 | 0.25 |
| Taurine | 275 ± 13a | 227 ± 32a | 340 ± 15b | 344 ± 15b | <0.001 |
| *L-Threonine* | *459.7 ± 28.1* | *468.9 ± 22.7* | *443.2 ± 41.6* | *609.7 ± 100.7* | *0.11* |
| Threonine | 442.8 ± 28.1 | 391.6 ± 55.6 | 436.3 ± 40.7 | 596.9 ± 108.6 | 0.15 |
| Tryptophan | 132.3 ± 31.5 | 57.8 ± 9.1 | 106.4 ± 30.0 | 111.7 ± 27.7 | 0.38 |
| Tyrosine | 85.6 ± 6.2 | 75.0 ± 6.6 | 79.4 ± 7.4 | 112.8 ± 20.6 | 0.06 |
| Tyrosine | 81.4 ± 4.5 | 59.1 ± 8.8 | 78.2 ± 6.8 | 103.7 ± 18.8 | 0.053 |
| *Valine* | *333.0 ± 19.1* | *339.1 ± 26.1* | *322.2 ± 31.3* | *407.7 ± 43.4* | *0.21* |
| Valine | 332.2 ± 19.4 | 281.6 ± 42.2 | 310.3 ± 27.1 | 378.8 ± 41.3 | 0.32 |
| Lipid metabolites: acylcarnitines | | | | | |
| C2 | 24.6 ± 4.2 | 17.8 ± 3.5 | 26.3 ± 5.2 | 27.1 ± 4.1 | 0.69 |
| C3 | 0.14 ± 0.02 | 0.08 ± 0.01 | 0.10 ± 0.02 | 0.19 ± 0.05 | 0.06 |
| C3:1 | 0.07 ± 0.01 | 0.06 ± 0.01 | 0.07 ± 0.01 | 0.08 ± 0.01 | 0.62 |
| C4 | 0.32 ± 0.05a | 0.15 ± 0.01b | 0.21 ± 0.03ab | 0.28 ± 0.05ab | 0.034 |
| C3-DC (C4-OH) | 0.10 ± 0.01 | 0.08 ± 0.01 | 0.10 ± 0.02 | 0.12 ± 0.02 | 0.39 |
| C4:1 | 0.03 ± 0.00 | 0.03 ± 0.00 | 0.03 ± 0.00 | 0.03 ± 0.00 | 0.53 |
| C5 | 0.10 ± 0.01ab | 0.07 ± 0.01 | 0.10 ± 0.01ab | 0.12 ± 0.02b | 0.046 |
| C5-OH (C3-DC-M) | 0.09 ± 0.01 | 0.08 ± 0.00 | 0.10 ± 0.001 | 0.10 ± 0.01 | 0.12 |
| C12 | 0.06 ± 0.01 | 0.05 ± 0.00 | 0.06 ± 0.01 | 0.07 ± 0.01 | 0.12 |
| C14 | 0.08 ± 0.01 | 0.05 ± 0.00 | 0.09 ± 0.02 | 0.09 ± 0.01 | 0.06 |
| C14:1 | 0.08 ± 0.01 | 0.04 ± 0.01 | 0.07 ± 0.02 | 0.07 ± 0.01 | 0.27 |
| C14:1-OH | 0.01 ± 0.00a | 0.01 ± 0.00b | 0.02 ± 0.00a | 0.02 ± 0.00b | 0.004 |
| C14:2 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.33 |
| C14:2-OH | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.41 |
| C16:0 | 0.28 ± 0.05 | 0.14 ± 0.02 | 0.28 ± 0.09 | 0.28 ± 0.07 | 0.33 |
| C16-OH | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.02 ± 0.00 | 0.02 ± 0.00 | 0.28 |
| C16:1 | 0.07 ± 0.01ab | 0.04 ± 0.00a | 0.05 ± 0.01ab | 0.05 ± 0.01b | 0.04 |
| C16:1-OH | 0.02 ± 0.00 | 0.01 ± 0.00 | 0.02 ± 0.01 | 0.02 ± 0.01 | 0.09 |
| C16:2 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.54 |
| C18:0 | 0.09 ± 0.02ab | 0.08 ± 0.01a | 0.12 ± 0.03b | 0.12 ± 0.03ab | 0.02 |
| C18:1 | 0.27 ± 0.05 | 0.15 ± 0.02 | 0.26 ± 0.08 | 0.25 ± 0.06 | 0.46 |
| C18:1-OH | 0.04 ± 0.00 | 0.03 ± 0.00 | 0.04 ± 0.01 | 0.04 ± 0.01 | 0.38 |
| C18:2 | 0.03 ± 0.01 | 0.02 ± 0.00 | 0.05 ± 0.01 | 0.05 ± 0.01 | 0.23 |
| LysoPC a C14:0 | 9.30 ± 0.75a | 8.81 ± 0.77a | 11.0 ± 0.6ab | 13.0 ± 0.9bc | 0.002 |
| LysoPC a C16:0 | 185 ± 39a | 76.9 ± 10.8a | 157 ± 40ab | 152 ± 41b | 0.004 |
| LysoPC a C16:1 | 7.82 ± 1.57a | 1.53 ± 0.07b | 3.3 ± 0.85ab | 3.2 ± 0.7ab | 0.002 |
| LysoPC a C17:0 | 4.72 ± 1.29a | 1.76 ± 0.34b | 5.70 ± 1.89ab | 5.69 ± 1.83ab | 0.021 |
| LysoPC a C18:0 | 206.1 ± 51.2 | 94.8 ± 14.9 | 193.3 ± 54.5 | 179.2 ± 57.2 | 0.70 |
| LysoPC a C18:1 | 52.2 ± 12.3a | 14.7 ± 2.3b | 35.6 ± 10.4ab | 34.5 ± 9.4ab | 0.048 |
| LysoPC a C18:2 | 46.4 ± 12.8 | 14.4 ± 2.4 | 33.3 ± 11.7 | 33.6 ± 8.9 | 0.17 |
| LysoPC a C20:3 | 8.18 ± 2.19a | 1.31 ± 0.22b | 2.59 ± 0.91ab | 2.44 ± 0.64ab | <0.001 |
| LysoPC a C20:4 | 105.7 ± 23.9 | 47.9 ± 8.0 | 91.8 ± 29.8 | 77.6 ± 22.6 | 0.59 |
| LysoPC a C24:0 | 2.40 ± 0.08a | 2.00 ± 0.02b | 2.15 ± 0.10ab | 2.17 ± 0.08ab | 0.009 |
| LysoPC a C28:0 | 0.27 ± 0.06 | 0.16 ± 0.02 | 0.22 ± 0.05 | 0.27 ± 0.04 | 0.21 |
| LysoPC a C28:1 | 0.54 ± 0.12 | 0.38 ± 0.06 | 0.56 ± 0.12 | 0.63 ± 0.10 | 0.63 |
| PC aa C24:0 | 0.35 ± 0.06 | 0.28 ± 0.04 | 0.40 ± 0.06 | 0.37 ± 0.94 | 0.49 |
| PC aa C28:1 | 0.29 ± 0.06 | 0.14 ± 0.02 | 0.30 ± 0.08 | 0.32 ± 0.07 | 0.08 |
| PC aa C30:0 | 0.82 ± 0.16ab | 0.38 ± 0.05a | 0.84 ± 0.23ab | 0.96 ± 0.20b | 0.05 |
| PC aa C30:2 | 0.03 ± 0.01 | 0.01 ± 0.01 | 0.05 ± 0.02 | 0.03 ± 0.01 | 0.33 |
| PC aa C32:0 | 9.23 ± 1.58 | 4.65 ± 0.63 | 7.62 ± 1.81 | 7.81 ± 1.63 | 0.31 |
| PC aa C32:1 | 7.51 ± 1.23a | 1.49 ± 0.13b | 2.76 ± 0.70b | 2.57 ± 0.52ab | <0.001 |
| PC aa C32:2 | 0.62 ± 0.13a | 0.16 ± 0.02b | 0.55±0.17a | 0.65 ± 0.15a | <0.001 |
| PC aa C32:3 | 0.12 ± 0.02 | 0.07 ± 0.01 | 0.12 ± 0.03 | 0.14 ± 0.03 | 0.20 |
| PC aa C34:1 | 89.3 ± 17.8a | 32.8 ± 2.7b | 50.5 ± 12.7ab | 46.2 ± 10.2ab | 0.020 |
| PC aa C34:2 | 87.6 ± 22.1 | 36.4 ± 5.8 | 73.9 ± 23.1 | 74.7 ± 19.2 | 0.27 |
| PC aa C34:3 | 2.83 ± 0.68ab | 0.83 ± 0.12a | 1.90 ± 0.65ab | 1.74 ± 0.42b | 0.04 |
| PC aa C34:4 | 1.25 ± 0.28a | 0.38 ± 0.08b | 1.15 ± 0.30ab | 1.08 ± 0.30ab | 0.018 |
| PC aa C36:0 | 2.88 ± 0.63 | 1.71 ± 0.17 | 2.35 ± 0.75 | 2.08 ± 0.56 | 0.76 |
| PC aa C36:1 | 32.2 ± 7.1 | 11.9 ± 1.0 | 17.8 ± 5.0 | 15.9 ± 3.4 | 0.03 |
| PC aa C36:2 | 98.6 ± 29.3 | 30.7 ± 4.7 | 60.0 ± 19.4 | 38.8 ± 13.6 | 0.22 |
| PC aa C36:3 | 30.3 ± 8.3a | 6.1 ± 0.7b | 13.5 ± 4.0ab | 13.0 ± 2.7ab | 0.012 |
| PC aa C36:4 | 202.4 ± 35.7 | 100.1 ± 16.0 | 165.2 ± 41.2 | 131.5 ± 31.9 | 0.24 |
| PC aa C36:5 | 5.31 ± 0.96a | 1.35 ± 0.14b | 2.56 ± 0.62ac | 2.08 ± 0.47bc | <0.001 |
| PC aa C36:6 | 0.31 ± 0.06 | 0.13 ± 0.03 | 0.24 ± 0.05 | 0.26 ± 0.07 | 0.09 |
| PC aa C38:0 | 1.18 ± 0.26 | 0.58 ± 0.08 | 0.83 ± 0.25 | 0.82 ± 0.26 | 0.43 |
| PC aa C38:1 | 0.29 ± 0.08 | 0.19 ± 0.04 | 0.35 ± 0.08 | 0.25 ± 0.04 | 0.33 |
| PC aa C38:3 | 45.5 ± 11.6a | 11.0 ± 1.4b | 20.2 ± 7.3ab | 15.8 ± 4.3ab | 0.041 |
| PC aa C38:4 | 392.1 ± 77.2 | 242.1 ± 40.9 | 346.1 ± 88.8 | 272.3 ± 65.0 | 0.62 |
| PC aa C38:5 | 52.5 ± 12.3 | 17.9 ± 2.9 | 48.8 ± 12.5 | 36.7 ± 9.1 | 0.13 |
| PC aa C38:6 | 87.4 ± 18.1 | 39.3 ± 6.9 | 54.3 ± 11.4 | 49.1 ± 11.8 | 0.14 |
| PC aa C40:2 | 0.27 ± 0.05 | 0.13 ± 0.02 | 0.22 ± 0.05 | 0.18 ± 0.04 | 0.19 |
| PC aa C40:3 | 0.52 ± 0.11 | 0.22 ± 0.02 | 0.29 ± 0.08 | 0.28 ± 0.06 | 0.09 |
| PC aa C40:4 | 2.79 ± 0.69 | 1.72 ± 0.29 | 2.47 ± 0.79 | 2.24 ± 0.57 | 0.95 |
| PC aa C40:5 | 14.19 ± 3.54 | 8.97 ± 1.87 | 9.26 ± 2.70 | 9.75 ± 2.81 | 0.64 |
| PC aa C40:6 | 78.9 ± 18.0 | 38.1 ± 7.40 | 50.0 ± 13.0 | 45.4 ± 12.2 | 0.33 |
| PC aa C42:0 | 0.09 ± 0.02 | 0.05 ± 0.00 | 0.07 ± 0.01 | 0.06 ± 0.01 | 0.25 |
| PC aa C42:1 | 0.07 ± 0.01 | 0.04 ± 0.01 | 0.06 ± 0.02 | 0.06 ± 0.01 | 0.67 |
| PC aa C42:2 | 0.14 ± 0.03 | 0.07 ± 0.01 | 0.10 ± 0.02 | 0.09 ± 0.02 | 0.30 |
| PC aa C42:4 | 0.18 ± 0.04 | 0.09 ± 0.01 | 0.15 ± 0.03 | 0.15 ± 0.04 | 0.61 |
| PC aa C42:5 | 0.23 ± 0.05 | 0.11 ± 0.01 | 0.17 ± 0.05 | 0.15 ± 0.03 | 0.40 |
| PC aa C42:6 | 0.48 ± 0.10 | 0.23 ± 0.02 | 0.28 ± 0.06 | 0.29 ± 0.05 | 0.09 |
| PC ae C30:0 | 0.15 ± 0.01ab | 0.11 ± 0.01a | 0.15 ± 0.03ab | 0.17 ± 0.03b | 0.016 |
| PC ae C30:1 | 0.05 ± 0.01 | 0.04 ± 0.01 | 0.04 ± 0.01 | 0.05 ± 0.01 | 0.76 |
| PC ae C30:2 | 0.35 ± 0.10 | 0.33 ± 0.09 | 0.37 ± 0.10 | 0.44 ± 0.09 | 0.82 |
| PC ae C32:1 | 0.73 ± 0.14 | 0.29 ± 0.05 | 0.53 ± 0.16 | 0.55 ± 0.12 | 0.13 |
| PC ae C32:2 | 0.13 ± 0.02 | 0.06 ± 0.01 | 0.11 ± 0.03 | 0.11 ± 0.02 | 0.10 |
| PC ae C34:0 | 0.57 ± 0.11 | 0.29 ± 0.04 | 0.62 ± 0.17 | 0.68 ± 0.17 | 0.23 |
| PC ae C34:1 | 3.62 ± 0.72 | 1.72 ± 0.26 | 2.98 ± 0.09 | 3.03 ± 0.78 | 0.44 |
| PC ae C34:2 | 0.95 ± 0.21 | 0.423 ± 0.07 | 1.16 ± 0.37 | 1.29 ± 0.34 | 0.07 |
| PC ae C34:3 | 0.35 ± 0.07 | 0.20 ± 0.03 | 0.34 ± 0.09 | 0.36 ± 0.08 | 0.58 |
| PC ae C36:0 | 0.37 ± 0.04 | 0.22 ± 0.02 | 0.35 ± 0.08 | 0.33 ± 0.07 | 0.24 |
| PC ae C36:1 | 1.22 ± 0.26 | 0.52 ± 0.07 | 1.09 ± 0.29 | 1.07 ± 0.24 | 0.14 |
| PC ae C36:2 | 1.76 ± 0.45 | 0.70 ± 0.10 | 1.63 ± 0.51 | 1.71 ± 0.41 | 0.16 |
| PC ae C36:3 | 0.71 ± 0.15 | 0.26 ± 0.04 | 0.48 ± 0.16 | 0.51 ± 0.13 | 0.14 |
| PC ae C36:4 | 6.43 ± 1.29 | 3.24 ± 0.52 | 5.95 ± 0.66 | 5.71 ± 1.57 | 0.48 |
| PC ae C36:5 | 2.42 ± 0.55 | 1.12 ± 0.20 | 1.96 ± 0.66 | 1.84 ± 0.50 | 0.60 |
| PC ae C38:0 | 1.49 ± 0.28 | 0.55 ±0.07\* | 0.82 ± 0.15 | 0.73 ± 0.16\* | 0.006 |
| PC ae C38:1 | 0.46 ± 0.10 | 0.14 ± 0.02\* | 0.30 ± 0.08 | 0.27 ± 0.05 | 0.09 |
| PC ae C38:2 | 1.19 ± 0.34 | 0.37 ± 0.05 | 0.82 ± 0.28 | 0.83 ± 0.20 | 0.09 |
| PC ae C38:3 | 1.12 ± 0.22a | 0.35 ±0.02b | 0.69 ± 0.17ab | 0.65 ± 0.16ab | 0.009 |
| PC ae C38:4 | 7.53 ± 1.57 | 4.43 ± 0.70 | 9.38 ± 2.91 | 7.99 ± 2.12 | 0.61 |
| PC ae C38:5 | 6.82 ± 1.46 | 3.80 ± 0.64 | 5.91 ± 1.93 | 5.65 ± 1.76 | 0.76 |
| PC ae C38:6 | 1.92 ± 0.38 | 0.88 ± 0.15 | 1.60 ± 0.47 | 1.61± 0.47 | 0.38 |
| PC ae C40:1 | 6.40 ± 1.58 | 2.74 ± 0.43 | 6.01 ± 1.80 | 4.39 ± 1.21 | 0.50 |
| PC ae C40:2 | 0.54 ± 0.12 | 0.23 ± 0.04 | 0.47 ± 0.15 | 0.47 ± 0.15 | 0.40 |
| PC ae C40:3 | 0.74 ± 0.10 | 0.35 ± 0.07 | 0.60 ± 0.16 | 0.43 ± 0.12 | 0.06 |
| PC ae C40:4 | 3.77 ± 0.81 | 1.69 ± 0.26 | 3.68 ± 1.16 | 3.14 ± 0.87 | 0.43 |
| PC ae C40:5 | 1.40 ± 0.29 | 0.77 ± 0.11 | 1.31 ± 0.38 | 1.24 ± 0.36 | 0.73 |
| PC ae C40:6 | 2.06 ± 0.49 | 1.03 ± 0.16 | 1.88 ± 0.51 | 1.80 ± 0.50 | 0.63 |
| PC ae C42:0 | 1.07 ± 0.15a | 0.64 ± 0.02ab | 0.71 ± 0.06ab | 0.67 ± 0.05b | 0.007 |
| PC ae C42:1 | 0.54 ± 0.14 | 0.24 ± 0.04 | 0.39 ± 0.09 | 0.32 ± 0.07 | 0.36 |
| PC ae C42:2 | 0.41 ± 0.11 | 0.16 ± 0.03 | 0.23 ± 0.07 | 0.22 ± 0.05 | 0.30 |
| PC ae C42:3 | 1.09 ± 0.25 | 0.43 ± 0.05 | 0.64 ± 0.16 | 0.55 ± 0.14 | 0.13 |
| PC ae C42:5 | 1.15 ± 0.22 | 0.91 ± 0.12 | 1.07 ± 0.21 | 1.11 ± 0.18 | 0.84 |
| PC ae C44:3 | 0.06 ± 0.01 | 0.03 ± 0.01 | 1.07 ± 0.21 | 0.04 ± 0.01 | 0.47 |
| PC ae C44:4 | 0.09 ± 0.02 | 0.06 ± 0.01 | 0.07 ± 0.02 | 0.07 ± 0.01 | 0.79 |
| PC ae C44:5 | 0.16 ± 0.03 | 0.08 ± 0.01 | 0.10 ± 0.02 | 0.09 ± 0.02 | 0.08 |
| PC ae C44:6 | 0.08 ± 0.02 | 0.05 ± 0.01 | 0.07 ± 0.02 | 0.07 ± 0.02 | 0.48 |
|  | | Sphingolipids | |  | |
| SM (OH) C14:1 | 0.48 ± 0.09 | 0.29 ± 0.05 | 0.80 ± 0.26 | 0.87 ± 0.28 | 0.50 |
| SM (OH) C16:1 | 0.27 ± 0.06 | 0.21 ± 0.04 | 0.39 ± 0.12 | 0.45 ± 0.13 | 0.43 |
| SM (OH) C22:1 | 4.77 ± 1.09 | 2.68 ± 0.51 | 5.58 ± 1.91 | 6.27 ± 1.92 | 0.50 |
| SM (OH) C22:2 | 1.60 ± 0.37 | 0.88 ± 0.16 | 1.92 ± 0.68 | 2.98 ± 0.60 | 0.42 |
| SM (OH) C24:1 | 2.49 ± 0.63 | 1.28 ± 0.33 | 1.99 ± 0.68 | 2.26 ± 0.78 | 0.79 |
| SM C16:0 | 36.47 ± 8.47 | 19.29 ± 4.02 | 27.06 ± 8.09 | 30.23 ± 8.74 | 0.73 |
| SM C16:1 | 3.18 ± 0.73 | 1.72 ± 0.33 | 2.8 ± 0.91 | 2.90 ± 0.81 | 0.79 |
| SM C18:0 | 4.09 ± 0.90 | 2.67 ± 0.51 | 3.54 ± 1.09 | 3.83 ± 1.18 | 0.95 |
| SM C18:1 | 1.25 ± 0.26 | 0.78 ± 0.14 | 1.36 ± 0.43 | 1.45 ± 0.43 | 0.82 |
| SM C20:2 | 0.15 ± 0.04 | 0.08 ± 0.02 | 0.13 ± 0.05 | 0.10 ± 0.02 | 0.36 |
| SM C22:3 | 0.20 ± 0.07 | 0.10 ± 0.03 | 0.20 ± 0.10 | 0.13 ± 0.05 | 0.27 |
| SM 24:0 | 19.16 ± 4.63 | 9.11 ± 1.89 | 14.55 ± 4.81 | 16.71 ± 4.84 | 0.63 |
| SM C24:1 | 27.21 ± 6.25 | 13.51 ± 2.70 | 16.81 ± 4.75 | 18.30 ± 4.55 | 0.47 |
| SM C26:0 | 0.14 ± 0.03 | 0.07 ± 0.01 | 0.10 ± 0.03 | 0.14 ± 0.04 | 0.62 |
| SM C26:1 | 0.25 ± 0.06 | 0.12 ± 0.02 | 0.18 ± 0.06 | 0.16 ± 0.04 | 0.36 |

1 NMR results are in *italics;* DI-LC-MS/MS results are in standard text. The abundance of each species is presented as mean ± SEM. Log-transformed data were analyzed by one-way ANOVA followed by Bonferroni’s post-hoc test. Means within rows with the same superscripts are not significantly (p<0.05) different from each other.

Table 3. Liver phospholipid profile

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Lipid Species  (nmol/mg liver) | LFD (n=8) | HFD (n=8) | LOW (n=8) | REG (n=8) | p-value |
| Phosphatidylcholine | 83.7 ± 3.3 | 89.3 ± 3.0 | 87.1 ± 3.2 | 78.8 ± 6.5 | 0.34 |
| Phosphatidylethanolamine | 38.5 ± 1.3 | 41.6 ± 2.6 | 41.6 ± 1.7 | 36.8 ± 3.4 | 0.41 |
| PC:PE | 2.17 ± 0.05 | 2.18 ± 0.09 | 2.11 ± 0.09 | 2.16 ± 0.08 | 0.92 |